Acoustic Localization and Classification of MMOD Impacts on Space Structures Using Deep Learning Networks, Phase I

Completed Technology Project (2018 - 2019)

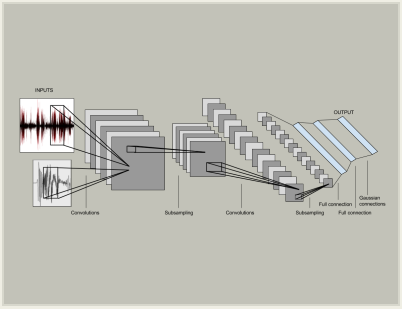
Project Introduction

Micrometeor and Orbital Debris (MMOD) impacts on spacecraft and large space structures are a significant hazard that can compromise mission success and threaten to endanger the lives of crew. Acoustic emission (AE) signals and impact shock generated by MMOD impacts can be detected by an array of inexpensive, replaceable, wireless surface sensor units affixed to the external surfaces of the spacecraft or space structure. However, due to the complexity of interpreting the AE signals, the determination of impact location and severity of consequent damage is greatly complicated by variations is structure geometry, sensor location, and sensor state. We propose to develop advanced Deep Learning Neural Network (DLNN) classifiers using empirical and model-generated training data to detect the occurrence of MMOD impacts, determine the location of the impact site, and classify the severity of consequent damage. Through accurate estimation of the severity of the damage, appropriate maintenance actions can be performed. Phase I will focus on demonstrating the feasibility of the approach on simple metal structures designed to approximate Whipple shielding and low velocity impacts. Phase II will more fully develop the approach and extend it to more complex geometries, composite materials, and hypervelocity impacts.

Anticipated Benefits

For large space structures, such the International Space Station or the Lunar Orbital Platform-Gateway, long mission lifetimes mean significant accumulation of damage from hypervelocity MMOD impacts over time. Detection and localization of impacts and assessment of damage to these structures by DLNN algorithms based on acoustic emission and impact shock signals can improve system resiliency by providing astronaut crews with critical information to isolate damaged modules and implement repairs.

As AE sensors become more cost-affordable, they will be deployed more widely. There are significant opportunities for using adaptive dynamic DLNN-based algorithms to detect impact events and assess consequent damage that can work with a wide variety of different structures (e.g., COPVs). Rapid identification and assessment of impact damage will improve system reliability and increase mission lifetimes while decreasing maintenance costs.



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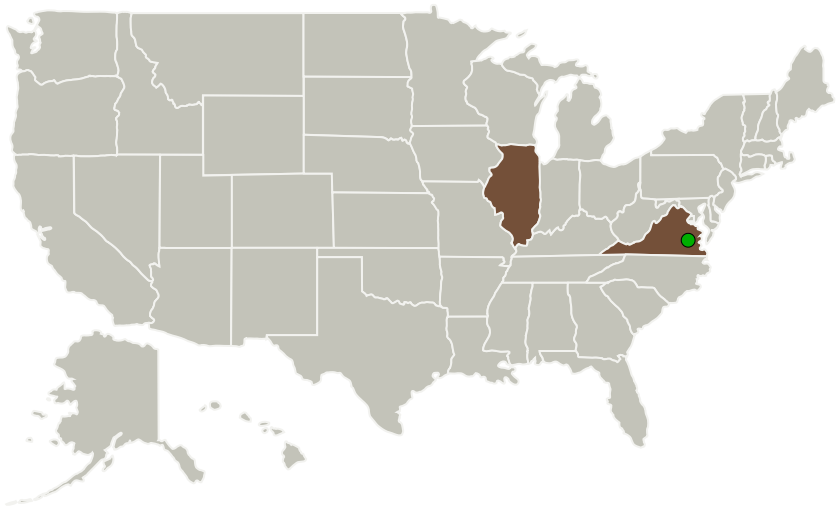
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Orbital Transports, LLC	Lead Organization	Industry Small Disadvantaged Business (SDB)	Chicago, Illinois
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Illinois	Virginia

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141203)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Orbital Transports, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

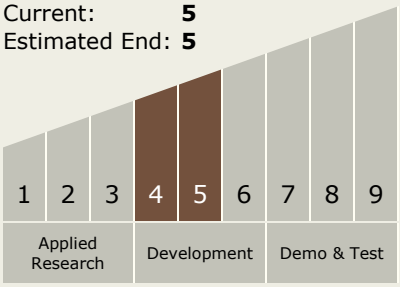
Carlos Torrez

Principal Investigator:

David Hurst

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



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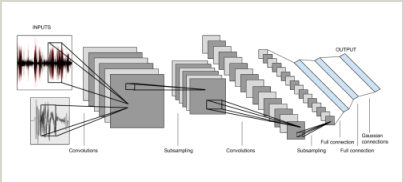
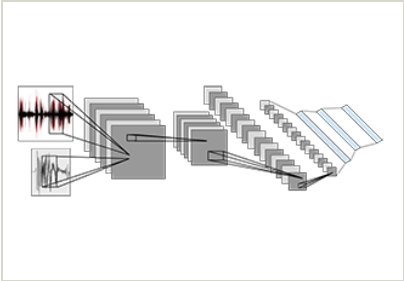
Images



Briefing Chart Image
Acoustic Localization and Classification of MMOD Impacts on Space Structures Using Deep Learning Networks, Phase I
(https://techport.nasa.gov/image/127305)



Final Summary Chart Image
Acoustic Localization and Classification of MMOD Impacts on Space Structures Using Deep Learning Networks, Phase I
(https://techport.nasa.gov/image/132185)

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.4 Information Processing
    - TX11.4.4 Collaborative Science and Engineering

Target Destinations

The Moon, Earth